Geographic Data Sharing

Continuing Political and Cultural Barriers Amid a Trend toward Increased Openness

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1. Introduction

Scientific data gains value with use. For scientific inquiry to advance, data must be shared between scientists, research centers, university and governmental institutions; across disciplines; and even across borders. Geography as a discipline has long recognized the value of sharing data and has even established formal national and international mechanisms to facilitate data sharing. Nevertheless, many barriers to open sharing of data remain.

Historically, the linkage between political power and the control detailed geographic information (especially maps) restricted open access to geographic data. Today governments are generally more willing to share their geographic data, but they still may restrict access to “sensitive” data, especially very high resolution data (Harris, C. 2003). Governments may also impose other restrictions such as limiting commercial or other uses deemed inappropriate. In general, however, the trend both nationally and internationally is for more free and open sharing of data. Yet we now face a situation where more data have been collected and made available in the past five years than were available in all of history before that (Hey 2006). This raises new challenges in data sharing. Some of these challenges are still political such as bridging the digital divide between developed and developing nations, but some barriers are rooted in the actual culture of geographic disciplines, and, of course, some barriers are because of technical limitations. In fact, reading the literature one might think that the primary impediments are technical in nature, but technology rapidly evolves in response to new needs and larger data volumes while the sociopolitical barriers to data sharing are often more intractable.

This paper describes the current challenges and outlines how geographic (especially physical geographic) data sharing is evolving as a significant factor

in the development of geographic disciplines and future of the “information society”.

2. Policy Considerations

2.1. Background and Context

Geographic information, notably cartographic information, has long been linked to state power and empire (Cosgrove 2001 among others). With the growth of sophisticated mapping technologies since the second World War and especially in the 1990s with high resolution remote sensing, states have continued to have an interest in regulating and controlling access to geographic information for both military and economic reasons (Harris C. 2003). At the same time, there has been a movement both within the U.S. and internationally to increase sharing of geographic data. This movement is partially rooted in a scientific tradition of data sharing (which varies across disciplines) and is augmented by the growing government and scientific imperative to conduct more interdisciplinary and synthetic studies (ICSU 2004). The growth in commercially produced geographic data, notably high resolution remote sensing imagery, has also led governments to increased “transparency” (Baker et al. 2001).

The basis for U.S. policy on geographic data sharing is found in the Office of Management and Budget Circular A-16 (OMB 2002). This Circular was originally issued in 1953, revised in 1967, and revised again in 1990. The purpose of the 1953 Circular was “to insure (sic) that surveying and mapping activities may be directed toward meeting the needs of federal and state agencies and the general public, and will be performed expeditiously, without duplication of effort.” The 1967 revision extended the “Responsibility for Coordination” and establishes some extensive reporting requirements. In 1990 the Circular expanded to include not only surveying and mapping, but also the related

spatial data activities. Specifically, it included geographically referenced computer-readable (digital) data. The 2002 updated Circular calls for continued improvements in spatial data coordination and the use of geographical data. The revision describes an integrated infrastructure system approach to support multiple government services and electronic government. This is the National Spatial Data Infrastructure initially created by President Clinton in 1994 (Clinton 1994) which includes a single mode of access to the data:

> The National Spatial Data Clearinghouse is an electronic service providing access to documented spatial data and metadata from distributed data sources. These sources include a network of data producers, managers, and users, linked through the Internet and other communications means, and accessible through a common interface. All spatial data collected by federal agencies or their agents, as described in section 5, will be made available through the Clearinghouse. Spatial data users will have access to the NSDI through the National Spatial Data Clearinghouse.

I discuss the NSDI in greater detail in section 5.

Data sharing policy has followed a similar arc at the international level. Perhaps it started with the ground breaking 1945 article by Vannevar Bush (Bush 1945), the Director of the US Office of Scientific Research and Development, but there has been a solid post war tradition in the open international exchange of (at least geophysical) data. This was codified during the International Geophysical Year of 1957-8 with the establishment of the World Data Center System, which continued to freely share data across the Iron Curtain during the Cold War. Another significant development from the same era was Article III-1c from the Antarctic Treaty of 1959, which stated “scientific observations and results from Antarctica shall be exchanged and made freely available.” Yet, similar to the

situation in the U.S., it was in the 1990s that the concept of international data sharing really took hold and a variety of international policies calling for the free and open exchange of data were developed. Notable examples relevant to geography include:[1]

- the Twelfth World Meteorological Organization (WMO) Congress, Resolution 40 (Cg-XII, 1995)
- the Thirteenth WMO Congress, Resolution 25 (Cg XIII, 1999)
- the UN Intergovernmental Oceanographic Commission (IOC) Data Management Policy for Global Ocean Programs, adopted March 1993:
- the International Council of Science (ICSU) 1996 General Assembly Resolution
- the ICSU Assessment on Scientific Data and Information (ICSU 2004)
- International Social Science Council General Assembly Social Science Data Management Policy, Paris, 1994

Furthermore it is now generally recognized that international science organizations have an obligation to promote broader data sharing. These organizations include ICSU's Committee on Data for Science and Technology (CODATA) and the Global Spatial Data Infrastructure (GSDI) Association (ICSU 2004, de Sherbinin and Chen 2005).

2.2. Characteristics of Data Policies

In examining the Global Monitoring for Environment and Security(GMES) project Harris and Browning (2003) identify six considerations of data policy:

1. ownership, privacy and confidentiality;
2. intellectual property rights and associated legal frameworks;

[1] See http://www.codata.org/data_access/policies.html and http://globalchange.gov/policies/intl-policies.html for good compilations of international data policies.

3. standards and metadata;
4. licensing, distribution and dissemination;
5. pricing policy;
6. archiving policy.

This global environmental context clearly includes significant geographic data, so it would be reasonable to consider these factors when looking at geographic data sharing policies in general. Curiously, given the GMES context, Harris and Browning did not explicitly list national security concerns as a consideration. Further, some of the listed considerations overlap to some degree. Therefore, examining four high-level considerations of national and international policy should provide sufficient context for discussion: national security concerns, commercial and economic considerations, individual concerns (privacy, personal ownership, etc.), and intellectual property rights (and related legal concerns).

It is also important to recognize that geographic data are produced by many different types of institutions that all have their own considerations and objectives. These institutions include statistical institutes, mapping agencies, natural resource management institutions, environmental monitoring and regulation bodies, Earth observation organizations, and others. Just within the U.S., 18 different government departments and agencies are members of the FGDC, and each of these departments contains multiple offices.

2.3. National Security and Commercial Considerations

In the immediate aftermath of World War II, the U.S. and other major powers became intensely secretive and restrictive in their dissemination of detailed geographic information, especially high resolution remote sensing. This secretive approach emerged largely from the fear of the sort of surprise military attacks that characterized much of the War and led to much

international tension (Leghorn and Herken 2001). Despite some efforts to the contrary, notably President Eisenhower's rejected Open Skies proposal (Eisenhower 1955), extreme restrictions on detailed imagery and other information dominated the Cold War era. The Soviet downing of a U.S. U-2 spy plane in 1960 and the subsequent fall out characterized the secrecy and tensions of the era.

With the fall of the Berlin Wall in 1989 and the end of the Cold War, there has been a significant move towards increased openness. The question of when military secrecy should dominate is still an ongoing debate (Preston 2001) and there is still a state imperative to manipulate or control access to geographic data for political purposes (Harris, C. 2003), but the trend is toward more and higher resolution data becoming available. Much of this has been driven by the commercial sector. The world's first truly commercial earth-observation satellite, Space Imaging's IKONOS, successfully launched in September 1999, collects panchromatic (black and white) images with better than 1-m resolution, and these data are readily available for purchase. More significantly, IKONOS and even higher resolution imagery is readily viewable for many parts of the world in the wildly popular Google Earth™ software (http://earth.google.com).

Commercial earth-observation satellites now blur the distinction between civil and military imaging satellites. On the one hand, satellites are being financed, built, and operated by private firms seeking to create profitable businesses by selling satellite imagery and services. On the other hand civilian earth-observation enterprises in Europe, Canada, and Russia are increasingly focused on selling data in the commercial satellite imagery market to help cover their operating costs (Baker et al. 2001).

Global Positioning System (GPS) data are another example of the trend toward relaxed security restrictions. GPS was originally developed for military purposes, but in 1996 President Clinton directed that GPS be a dual civilian and military use system. Plans were later announced to upgrade the system for enhanced civilian user accuracy. Then in 2000, the policy of "selective availability" was discontinued, allowing users outside the US military to receive a full quality signal.

2.4. Individual and Privacy Considerations

One of the direct impacts of this increased availability of high (spatial and temporal) resolution imagery and positioning is a new form of privacy concern. The ability to combine GPS data, high resolution data, and data with other attributes such as property records or purchasing information leads to a desire by some to protect their "locational privacy" (Kisselburgh, in press[2]). Data polices ensuring individual confidentiality when humans are used as research subjects are well established in the fields of medicine and statistics. In the U.S., there is an explicit Office for Human Research Protections within the Department of Health and Human Services established under law, and other agencies have explicit confidentiality guidelines for researchers. In contrast, locational privacy has not been explicitly considered in the data policy context. Indeed, the concept is still being explored in the courts. While discussion of the legal evolution of privacy concepts is beyond the scope of this paper, it is important to recognize that this concept is ripe for exploration by human geographers in how people define their personal boundaries and identities in a world of rapidly changing technologies that lead to shifting concepts of space, intrusion, and expectations of privacy and isolation.

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[2] See also Kisselburgh's essay at
http://www.anonequity.org/weblog/archives/2006/10/technologies_of_identification.php

2.5. Intellectual Property Issues

Another evolving policy area is in the consideration of the intellectual property rights (IPR) of data producers and knowledge holders. Generally, data themselves cannot by copyright (facts are not creative works), but there is ongoing debate as to whether database structures or derived data products can be protected by copyright or contractual restrictions. A major player in this debate is the UN's World Intellectual Property Organization (WIPO), and there is significant variance of opinion between developing and developed countries in the protection of intellectual property. A new player in the debate is CODATA's Global Information Commons for Science initiative, which is working collaboratively with the Science Commons (http://sciencecommons.org/) to explore legally sustainable ways to ensure open and fair use of scientific data.

In geography, the IPR issue may be most acute in the growing use of local and traditional knowledge (LTK). LTK is increasing being used in climatology and bio-geography (see for example, Cunningham 2003, Huntington and Fox 2005, and Krupnik and Jolly 2002), but the treatment of the rights of indigenous knowledge holders is variable. The 1992 Convention on Biological Diversity (Article 8(j)) requires each party to " respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities...with the approval and involvement of the holders of such knowledge, innovations and practices and encourage the equitable sharing of the benefits arising from the utilization of such knowledge, innovations and practices." But all of this is "Subject to its national legislation," which varies immensely. For example, there is some discussion in Canada about how the section of Canada's Constitution Act of 1982 on the rights of aboriginal peoples of Canada may be used to protect the IPR of native knowledge (David Hik, IPY Secretariat, pers. comm.). Other countries, notably many developing countries, do not have the same legally protective frameworks.

2.6. International Capacity Building

On the international level another emerging issue is bridging the "digital divide" between developing and developed nations. The two phase World Summit on the Information Society was a mechanism to promote capacity building and education initiatives to ensure that all countries can benefit from the new technological opportunities for the production and sharing of scientific information and data (WSIS 2003, WSIS 2005). This isn't a data policy issue per se, but open and equitable data policies would contribute to the success of the effort. Other contributions could include technology transfer programs and the development of appropriate simple and durable technologies for the developing world. The "$100 laptop" or One Laptop Per Child initiative is an excellent example of this (http://www.laptop.org).

3. State and Local Institutional Data Sharing

Different state and local institutions may or may not be subject to national laws and policies regarding data sharing. Regardless, these institutions face unique challenges in sharing their data and accessing data from other related institutions.

Craig (1995), described one of the most significant challenges in data sharing is simply institutional inertia. Organizations are so focussed on their own specific goals that they are often blind to how a small amount of additional effort to make data more broadly available could greatly benefit others or how they might be able to access additional data to serve their own needs. Craig says this institutional inertia manifests itself in three ways: a general refusal to cooperate, shortsighted or overly specific selection of technologies, and the use of idiosyncratic data formats, types or classifications. Others describe similar issues such as inflexibility, varying philosophies in system design, top-down

management that is not in touch with the fundamental problems on the ground, distrust of how data will be used by others, etc (Onsrud and Rushton 1995). Overall, many of these problems are rooted in the general lack of incentive to share data. Most would agree that if everyone readily shared their data then distribution and integration costs for everyone would go down, but the costs and benefits of data sharing are not equally distributed. The beneficiaries of institutional data sharing are largely analysts, policy makers, and to a certain degree the general public. On the other hand, the cost of sharing data falls on the operational data collectors, database designers, and the like. These operational people usually have very specific needs for their data and making their data more broadly available provides no additional benefit. While cheaper and more powerful technology, standardization, and the general increase in digital data, has made data sharing easier and less expensive, the fundamental problem of lacking incentive remains.

So a significant barrier to institutional data sharing is individual behavior. Correspondingly, individual behavior appears to be the most effective way to break down that barrier. For example, Harvey (2001) talks about the importance of individual collaboration in actor networks. Craig (2005) highlights individual behavior more specifically, by identifying what he calls the "white knights" of data sharing in an examination of the Minnesota SDI. He describes how certain key individuals were instrumental in developing major components of the Minnesota SDI. These individuals all shared three common traits: idealism, enlightened self-interest, and involvement in a professional culture, and Craig suggests that encouraging these traits in the GIS community would increase data sharing. I would argue that it goes well beyond the GIS community and that all geographers (and other scientists) should receive some basic training in the principles and practices of data management and the overall benefits of data sharing as part of their scientific education. This would not only foster

some of the necessary idealism, but would also build a greater appreciation of the value of data management and the professional effort involved.

4. Community and Individual Level Data Sharing

4.1. Changing the Culture of Science.

Interdisciplinary science requires a fundamental change in the way scientists do research. Concurrently, we need a shift in scientific culture so that publishing quality data and metadata is valued and respected as much publishing research results. The current culture of science is sometimes described as “publish or perish:” a researcher develops a hypothesis, gathers data and tests the hypothesis, then publishes her results in peer-reviewed literature. The researcher is then finished with the project. The career and esteem of that researcher is measured by the quality and frequency of his or her publications. In the new model, which we might describe as “preserve or perish,” researchers should be evaluated on the quality and availability of their data as well as their published results. The researcher is not finished until he or she has also published the data, which means ensuring they are well described, well preserved, and readily available. Some fields of science, notably genomics, have strongly adopted this approach, but it is a relatively new concept in most fields of geography. Many individual geographers are very resistant to make their data available in a timely fashion. They fear their data will be misused; they will not be recognized; others will publish similar results before they do. In short, there it is an issue of trust. One way to build greater trust is to ensure researchers get proper credit for producing and publishing data. When possible, researchers should formally cite their use of data just as they would a journal article, crediting the researchers who collected, compiled, and vetted the data.

The FGDC Content Standard for Metadata is the most broadly adopted metadata standard in geography and includes specific fields for a data citation, but they are often not used. More importantly, journals (and reviewers) do not require authors to cite their use of data and in some cases may actively discourage formal data citation. Part of the resistance of journals to accepting data citations is rooted in a similar resistance to allowing formal citation of web sites in that they are seen as mutable and impermanent. The American Geophysical Union has addressed this by requiring that data cited in their journals by archived in a formal data center (http://www.agu.org/pubs/data_policy.html). A farther reaching example is that the German National Library of Science and Technology includes data "publications" in their catalog, provided the data citation includes a Digital Object Identifier (DOI) as a way to ensure the data can be permanently found and referenced (Klump et al. 2006). This is an important development because these data references can be identified and tracked in formal citation databases allowing for better measurement of citation impact.

One aspect of data sharing closely related to the publication process is quality assurance of data, especially through some sort of peer review process. The concept of formal peer review of data has not yet been well explored, but could be an essential ingredient to a formal and well recognized data publishing process that could in turn change the culture of science leading to broader individual sharing of data.

4.2. Community Data Sharing

Geographic research is increasingly engaging local communities and involving these communities in the creation and use of geographic data. Craig et al. (2002) describe a variety of projects where planning professionals involve communities in neighborhood revitalization and urban planning; where environmental groups involve communities and the use of GIS to promote

environmental equity and address environmental racism; and where non-governmental organizations, aid organizations, and governmental agencies are linking communities to promote sustainable development. A central assumption of these projects is that community engagement, especially through the use of GIS, can empower people on the margins of society, but there are many challenges to assure equitable access to information and technology and to describe geographical realities in a way that is relevant to a community's perspective, knowledge base, or "way of knowing." These issues are most significant with the growing recognition of the importance and use of local and traditional knowledge (LTK).

LTK documentation and community-based based monitoring activities have amassed a large amount of data, information, and knowledge but, there is no data management system for storing, protecting, organizing and sharing this information on a broad scale. LTK is collected most often through interviews and stored on tapes (audio or video) or as written transcripts. These materials are often in the possession of individual investigators or community or regional archives that are not always accessible to the public (e.g. linked to library systems, or discoverable on the internet). There are few examples of this information being broadly searchable or available to the broader public (good examples that do exist include the Arctic Borderland Ecological Knowledge Co-op (http://www.taiga.net/coop) and the Local Fisheries Knowledge Project (http://www.st.nmfs.gov/lfkproject/). The issue is further complicated by a lack of consistent data collection protocols or standards and little effort to synthesize information across projects, regions, themes, or sources of information (e.g. linking knowledge from different communities or across disciplines). Even within a community itself means of access to data about that community may be inadequate. One reason for this inconsistent access is simply a lack of awareness of what research has been done within and across

communities. Broader education of both geographers and the communities themselves of the existence and value of this information could increase the level of data sharing. A resource for LTK or community-based monitoring data providers to post information about their efforts would be an invaluable resource (Shari Gearheard and Henry Huntington, pers. comm.)

5. Spatial Data Infrastructures and Other Technical Considerations

In geography the technical or systematic aspects of data sharing are typically described in terms of the Global and National Spatial Data Infrastructures (GSDI and NSDIs). The Mapping Science Committee of the National Research Council, which was instrumental in initiating the U.S. NSDI, defines the NSDI as the "materials, technology, and people necessary to acquire, process, store, and distribute geospatial data to meet a wide variety of needs" (MSC 1993). Groot and McLauglin (2000) say an SDI includes "the sources, systems, networks, standards, and institutional aspects involved in delivering spatially related data from diverse sources to the widest possible group of potential users at affordable costs". These are broad definitions and would seem to encompass most, if not all, means of distributing geographic data. Yet the U.S. NSDI has come to be an explicit system overseen by the Federal Geographic Data Committee and some major U.S. geographic data systems, especially in satellite remote sensing, are are not directly involved.

I would even argue that the explicit NSDI has not evolved significantly over the last decade. While there have been some significant advances such as the so-called Geospatial One-Stop (GOS, http://geodata.gov), SDIs still suffer from the basic problem discussed in section 3 that data providers often lack incentive to make their data available, and this is exacerbated by the complexity of the system. GOS has improved as the data access interface (especially after ESRI took it over), but making the data available to the system is still rather arcane

and not a routine part of most data collection operations except for the most dedicated GIS operations. This is an important point. The NSDI has largely been geared toward the GIS community and has therefore missed large groups of geographical data users, especially those in Earth sciences who have less of an explicit spatial focus and are more concerned with changes over time.

The very concept of a single user portal or clearinghouse, which has been a central operating principle of the NSDI from the beginning (FGDC 1997, MSC 1993, PDG 1999), may be flawed. While the desire for a single entry point is understandable, it is also somewhat misguided. Data users in different disciplines conceive of and search for data in fundamentally different ways. Lakoff and Johnson (1980) argue that people need a conceptual basis to understand something and that scientists invoke key metaphorical concepts to work observations into a coherent, consistent structure. Parsons and Duerr (2005) describe how these metaphors can vary from discipline to discipline and are bound to change over time, even within a given discipline. Therefore, data managers need to be aware of the conceptual basis of their user community to best present and enable access to their data. SDIs need to be much more flexible and explicitly user focussed. They also need to lower the technical barriers to putting data into the system.

Two recent developments have done much to improve the discoverability and broad accessibility of geographic data: the development of the Web Mapping Server (WMS) specification and the release of Google Earth. Both of these were developed outside the auspices of the NSDI (although WMS and related specifications are now being incorporated). These two developments are very distinct. WMS is a technical specification used by operational specialists to easily present map layers through Web and other interfaces, while Google Earth is a tool geared to very broad public use. But they share several important attributes. Both are flexible and have large growing user bases; both provide

relatively simple, open-source means of data publishing; and both have significant corporate backing. Google Earth is, of course, a proprietary tool. WMS is a community-based, open-source initiative under the auspices of the Open Geospatial Consortium (OGC), but arguably the success of WMS took off once ESRI joined the OGC and WMS was implemented in numerous proprietary desktop GIS tools, notably ESRI's ArcGIS.

The combination of a broad open-source community backed by significant corporate resource provides an interesting contrast to the top-down, government driven NSDI. It is important to note, however, that neither WMS nor Google Earth are true data sharing mechanisms. While Google Earth and WMS interfaces often provide links to the actual data, the tools themselves are only provide a means to share images. OGC has other specifications for sharing vector and raster data (Web Feature Server—WFS and Web Coverage Server—WCS), but these have not yet been as widely adopted because vendors are still developing robust clients. Meanwhile, Google Earth (and other virtual globes) are evolving rapidly and it is reasonable to assume that there will be tighter linkage between visualization and actual data acquisition in the future. Ultimately, I believe the government-driven NSDI and the broader data visualization approaches will merge into a more robust data sharing infrastructure. OGC specifications are already part of the NSDI and several virtual globes currently serve as WMS clients.

This shared governement/commercial/public approach is more typical of existing, well-established infrastructures such as utilities and transportation systems. If we are to develop a true data sharing infrastructure, we should think in terms of robustness and stability and focus more on standards, best practices, and formal professional development rather than specific and ever-changing technologies.

6. Conclusion

Geography has witnessed increasing openness and broader data sharing, especially in the last ten to fifteen years. Increased sharing has been driven largely by the growth of digital data and the accompanying increase in technical capacity coupled with a steady trend in policy toward encouraging more free and open access. Governments and individuals are increasingly recognizing that scientific and economic benefits grow with increased data access. Nonetheless, certain barriers to data sharing remain. Some of these barriers are the technical challenges of dealing with large and exponentially growing data volumes, but the more difficult barriers are rooted in the culture of geographic disciplines and the willingness of individuals to share their data. We have the means to share data, but do we have the will?

It is ironic that geography has led the way in the technical aspects of data sharing through GIS and SDIs, but many geographic disciplines lag well behind other scientific disciplines in their culture of data sharing. The overall discipline of geography needs to encourage more openness and a general spirit of collaboration by emphasizing that data management is a professional field in its own right, but that it is made more useful if all geographers contribute to its success. All geographers should receive some basic education in data management. This would help provide incentives for data sharing; would encourage broader adoption of best practices, such as rigorous data documentation; and would generally increase awareness of what data are potentially available. Only through broad and non-discriminatory data sharing and collaboration can we understand the complex interdisciplinary problems geographers are uniquely positioned to address.

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